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ON THE LATE-GLACIAL AND POST-GLACIAL HISTORY OF THE BALTIC

By Ernst Antevs

Probably no other inland sea has as great and many-sided a scientific interest as the Baltic. There, owing to an unusually happy combination of circumstances, those *varve,* annual laminae of, clays and silts were deposited which enabled Gerard De Geer and Ragnar Lidén to obtain the exact geochronology of the last 13,500 years. Extensive alterations of level since the disappearance of the last land ice have changed considerably the outline of the Baltic. At first exclusively supplied with fresh water by the vanishing ice sheet, at times connected with the ocean by sounds, and at other times separated from it, it also underwent great changes in salinity. Along with these variations there were marked changes in climate, fauna, and flora. Since time immemorial the shores of the Baltic have been the home of the Nordic race; and so the long history of this sea is geological, geographical, and archeological.

In this article only those features of the physical history of the Baltic will be treated the interpretation of which has recently undergone fundamental modifications and which are essential to the solution of other problems. Thus, I shall deal mainly with the changes of level[1] and shall only touch upon the climatic evolution and the immigration and changes of fauna and flora.

Amount of the Oscillations of Level in the Southern Baltic

The isobase of zero or line which marks the outer limit of late-glacial and post-glacial[2] upwarping of northern Europe—assuming sea level to have been constant—crosses Zealand in a northwest-southeast direction, touches Rügen and Pomerania, and continues in a curve towards the east-northeast.

Inside, or north, of this zero isobase at the disappearance of the ice the land was submerged. It has since undergone repeated elevations and subsidences. The net result is uplift.

Outside, or south, of the isobase of zero, on the contrary, the land lay higher than it does now. According to the German geologists North Germany then stood at the highest elevation it ever reached in all late-glacial and post-glacial time.[3] More probably the maximum elevation was attained somewhat after release from the ice, as seems to have been the case in southern New England.[4] Since the highest level was reached the region has probably undergone an almost uninterrupted slow subsidence down to its present level. As far as is known, there was no uplift during Ancylus time, i.e. the fresh-water stage of the Baltic in early post-glacial time.[5]

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[1] C. E. P. Brooks (The Evolution of Climate in North West Europe, *Quart. Journ. Royal Meteorol. Soc.,* No. 199, Vol. 47, 1921, pp. 173–194, London; reviewed by Ellsworth Huntington in *Geographical Review,* Vol. 12, 1922, pp. 126–130) largely bases his opinion of the causes of the climate of northern Europe in late Quaternary time on the old view of the changes of level.

[2] *Post-glacial* time, according to this chronology, begins the year after the bisection of the shrinking ice sheet at Ragunda in northern Sweden. The term *late-glacial* refers to the time occupied by the recession of the last ice sheet up to the event mentioned. See also the table on page 605 and the map on page 604.

How much higher North Germany stood in late-glacial and early post-glacial time has not been determined, as the only possible records of this have sunk below the level of the sea. A minimum figure of the elevation at a somewhat later stage, however, has recently been determined. When the ice edge receded over southern Sweden the southern Baltic formed an ice-ponded lake, which was drained to sea level when the ice edge left Mt. Billingen, northeast of Gothenburg, and a lower region was uncovered. This lowering of the Baltic amounted to 17 meters.[6] Consequently, the thresholds in the southwestern Baltic, at that time, stood at least 17 meters above the sea. Since the Darsser Schwelle, between Falster and the German mainland, now reaches a depth of 18 meters, the southwestern Baltic region then stood at least 35 meters higher than now. When the ice was receding from southern Sweden, the tract probably stood somewhat higher than this, although no reliable evidence has been presented of a higher stand than 35 meters. Statements as to very high elevation, particularly in early post-glacial (Ancylus) time, have been found to lack real basis. Thus, in the southwestern Baltic terrestrial and semiterrestrial formations—peat, for example—have only been met with down to a depth of about 20 meters, viz. on the Oderbank and at Travemünde.[7] The greatest depths at which such formations have been found north of the isobase of zero are 14 meters at Copenhagen[8] and 9 meters south of Bornholm.[9] The alleged evidence from the southeastern Baltic that the topographical conditions in the Leba-Rheda valley,[10] north-

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[3] C. Gagel: Die sogenannte Ancylushebung und die Litorinasenkung an der deutschen Ostseeküste, *Jahrbuch Königl. Preuss. Geol. Landesanstalt zu Berlin*, Vol. 31, 1910, pp. 203–226.

Theodor Otto: Der Darss und Zingst. Ein Beitrag zur Entwicklungsgeschichte der vorpommerschen Küste, *Jahresberich Geogr. Gesell. zu Greifswald*, Vol. 13, 1911–12, pp. 235–485; reference on pp. 312–316.

[4] Ernst Antevs: Recession of the Last Ice Sheet in New England, *Amer. Geogr. Soc. Research Ser. No. 11*, 1922.

[5] Gagel, *op. cit.*, p. 204.

Otto, *op. cit.*, pp. 310 and 321.

E. Geinitz: Diluvialstudien im östlichen Mecklenburg, *Archiv Vereins der Freunde der Naturgeschichte in Mecklenburg*, Vol. 66, 1912, p. 187. Rostock.

[6] G. Lundqvist: Den baltiska issjöns tappning och strandlinjerna vid Billingens nordspets, *Geol. Fören. Förhandl.*, Vol. 43, 1921, pp. 381–385. Stockholm.

[7] Gagel, *op. cit.*, p. 222.

Otto, *op. cit.*, p. 315.

[8] Ernst Antevs: Some Corrigenda, *Geol. Fören. Förhandl.*, Vol. 40, 1918, p. 892–893. Stockholm.

[9] K. A. Grönwall and V. Mitlhers: Kortbladet Bornholm, *Danmarks Geol. Unders.*, Ser. 1, No. 13, 1916; reference on pp. 236 and 244. Copenhagen.

[10] Alfred Jentzsch: Ueber einige Züge in der Oberflächengestaltung Westpreussens, *Zeitschr. Deutsch. Geol. Gesell.*, Vol. 42, 1890, pp. 613–618; reference on p. 617.

Idem: Das Präzisions-Nivellement Lauenburg-Neustadt-Rheda. Eine Studie zur Frage nach senkrechten Boden-Bewegungen, *Jahrbuch Königl. Preuss. Geol. Landesanstalt zu Berlin*, Vol. 33, 1912, Part II, pp. 367–384.

K. Keilhack: Die Stillstandslagen des letzten Inlandeises und die hydrographische Entwickelung des pommerschen Küstengebietes, *ibid.*, Vol. 19, 1898, pp. 90–152; reference on p. 145.

Idem: *Geol. Zentralbl.*, Vol. 22, 1915, No. 31.

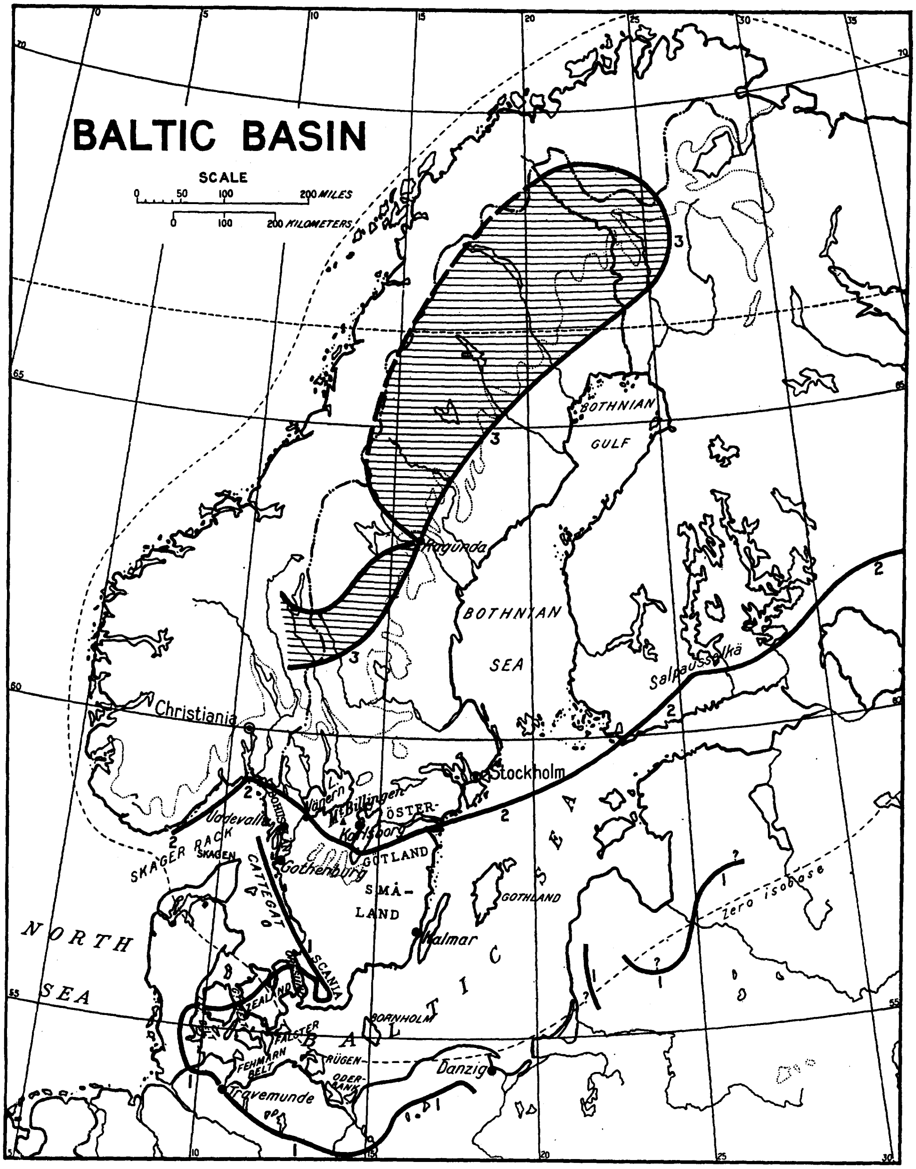

FIG. 1—Map illustrating the late-glacial and post-glacial history of the Baltic Basin. The numbered lines indicate the position of the ice edge at the beginning of (1) goti-glacial (after Gerard De Geer: Om naturhistoriska kartor över den baltiska dalen, *Pop. Naturvet. Revy*, 1914, pp. 189–200 and Pls. 1–4, Stockholm), (2) fini-glacial, and (3) post-glacial time respectively. Ice remnants in Sweden, at the beginning of the post-glacial epoch, are shown by shading. The light broken line is the zero isobase. (The base upon which these data are shown is Northwest Europe, No. 215, in Goode's Series of Base Maps, The University of Chicago Press, 1920; the scale is approximately 1:13,500,000.)

CHRONOLOGY (Gerard De Geer and Ragnar Lidén)			CHANGES OF LEVEL IN BOHUSLÄN (Ernst Antevs)	STAGES IN THE BALTIC (Modified from Henrik Munthe and others)
0	A.D. 1900			
1,000	Recent			
2,000			Present level reached	Limnaea: salinity decreases
3,000			Elevation	
4,000	Post-glacial			
5,000			Submergence (Tapes)	Littorina: salinity twice that at present; submergence
6,000			Elevation	
7,000			Submergence	
8,000		Bisection of ice remnant at Ragunda	Elevation	Ancylus: fresh-water inland sea; submergence
9,000	Fini-glacial	Ice retreat from the Fenno-Scandian moraines (inclusive) to Ragunda	Submergence	Sea connection through central Swedish straits
10,000			Elevation	Drainage of last Baltic ice lake at Billingen
11,000		Ice retreat from south Scania, the Danish Islands, and North Germany to the Fenno-Scandian moraines	Submergence Elevation	South Baltic ice lakes and fresh water inland seas
12,000			Depressed to marine limit, as released from the ice, but rising	
13,000	Goti-glacial	Central Scania released from the ice about 13,500 years ago		
13,500		Time represented in the outermost part of the zone unknown		

FIG. 2—Chronology for eastern and western Sweden. Intended to show the relationship between the principal events in eastern and western Sweden and to combine them with the De Geer-Lidén exact chronology.

The term goti-glacial is derived from Gothia, the modern Götaland or southern Sweden; fini-glacial has reference to the final stage of the ice recession.

The present surface salinity in the Baltic is: South of Scania 0.8 per cent, at Gothland 0.7 per cent, in the southern Bothnian Sea 0.5 per cent, and in the northern Bothnian Gulf 0.2 per cent. In the southern Öresund the surface salinity is 1.1 to 1.2 per cent, at Skagen 3 per cent and in the Atlantic 3.5 per cent.

west of Danzig, indicate an elevation in late-glacial time of at least 50 meters above the present seems to be illusory.[11] This is doubtless the case also with the evidence presented by Munthe [12] that the "river-channel-shaped depressions" in the Danish Belts and in the Öresund indicate the base of river erosion in Ancylus time; for Spethmann's[13] bathymetrical map shows clearly that these depressions cannot have been eroded by rivers, as they consist of series of narrow basins separated by thresholds which at some points are very shallow and broad. These depressions, as Gerard De Geer has orally pointed out, probably mark lines of fracture.

ANCYLUS LAKE—A FRESH-WATER INLAND SEA

In the beginning of the post-glacial epoch the Baltic was characterized by fresh water, as has been known for 35 years especially through Munthe's valuable studies of its subfossil fauna and flora. At the same time a well recorded and extensive transgression took place in the central and southern Baltic region. The fresh water proved in Munthe's opinion that the Baltic was a true lake separated from the sea. The Baltic of that time has therefore been called the Ancylus lake. The transgression has been explained by a more rapid rising of northern Scandinavia than of the southern part, by which the water masses were shifted southward causing the water level to rise there. This explanation assumes a very high elevation of the southern Baltic region.[14]

As the present writer [15] pointed out, however, the fresh water of the Ancylus lake can be explained without the assumption of its being excluded from the sea by referring it to an excessive supply of ice water from the ice sheet. This makes it unnecessary to accept the changes of level as set forth by Munthe, which are hardly acceptable in themselves and which disagree with evidence more recently obtained in western Sweden. A consideration of the conditions which govern the present salinity of the Baltic [16] will make clear the basis for this new view of it as a fresh-water inland sea during Ancylus time.

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[11] Gagel, *op. cit.*, p. 219.

E. Wunderlich: Postglaziale Hebung in Westpreussen und Hinterpommern, *Zentralbl. für Mineral., etc.*, 1914, pp. 464–468.

[12] H. Munthe: Studies in the Late-Quaternary History of Southern Sweden, *Geol. Fören. Förhandl.*, Vol. 32, 1910, pp. 1197–1293; reference on p. 1205. Stockholm.

[13] Hans Spethmann: Tiefenkarte der Beltsee, *Petermanns Mitt.*, Vol. 57, II, 1911, pp. 246–251 and Pl. 29.

[14] Munthe, *op. cit.*, p. 1205, Pl. 46B.

Idem: Studier öfver Gottlands senkvartära historia, *Sveriges Geol. Unders.*, Ser. Ca, No. 4, 1910; reference on pp. 36–38, 178, 205. Stockholm.

[15] Ernst Antevs: Post-glacial Marine Shell Beds in Bohuslän, *Geol. Fören. Förhandl.*, Vol. 39, 1917, pp. 247–425; reference on p. 257. Stockholm.

[16] Otto Pettersson: Resultaten af den internationella hafsforskningens arbete, *Kungl. Jordbruksdpt. Meddel. 14*, 1907; reference on p. 89. Stockholm.

Idem: Strömstudier vid Östersjöns portar, *Svenska Hydrograf.-biolog. Komm. Skrift.*, No. 3, 1908. Gothenburg.

Idem: Über Meeresströmungen, *Veröffentl. Inst. für Meereskunde*, No. 12, 1908. Berlin.

Otto Krümmel: Die deutschen Meere im Rahmen der internationalen Meeresforschung, *Veröffentl. Inst. für Meereskunde*, No. 6, 1904.

Idem: Handbuch der Ozeanographie, 2 vols., Stuttgart, 1907, 1911; reference in Vol. 1, p. 350.

PRESENT-DAY SALINITY OF THE BALTIC

At the present time the Baltic is connected with the ocean by the Öresund and the Fehmarn Belt.

The south Öresund, 8 meters deep, generally allows only an outward-flowing current to pass through. During long and continued northwesterly winds, however, a turn of the current sometimes sets in which carries some sea water across the threshold.

The Fehmarn Belt, on the sill between Falster and Darsserort, is at most 18 meters deep. Here a surface current usually flows outward to the Cattegat, while a bottom current flows inward to the Baltic. The outgoing surface current is formed by a mighty wedge-shaped layer of Baltic water of a homogeneous salinity of 0.7–0.8 per cent. The incoming undercurrent is brought about by a thin wedge of heavier water of 0.9–1.2 per cent salinity, as often as this is forced across the threshold by the excess of atmospheric pressure on the North Sea over that on the Baltic. When the conditions of atmospheric pressure are reversed the undercurrent does not get through, and the outgoing Baltic waters occupy the whole cross section of the channel.

To what degree and how rapidly the salt water which thus comes in across the thresholds is mixed with the brackish water of the Baltic is not yet fully made out; for, in spite of the fact that a lively circulation takes place in the inland sea, the presence of salty bottom layers, particularly, proves that the mixing is very incomplete. As it seems probable that the mixing of two water masses is rendered more difficult by great contrasts in their gravity or salinity, the mixing was probably still less effective in late-glacial and early post-glacial times than now.

In this connection the present conditions in lake Mälaren, at Stockholm, are significant because they are so well known, and because this lake is related to the Baltic much as the Baltic during long periods in late-glacial time was related to the Western Sea. It must be kept in mind, however, that the circulation and the mixing of the waters in Mälaren, no doubt, are less than was and is the case in the large Baltic.

The channel between Mälaren and the Baltic, the Norrström, in Stockholm, is exceedingly short and narrow, and the threshold lies about 4 meters below sea level.[17] Mälaren has fresh water and the Baltic brackish. If, as sometimes happens, the water level of the Baltic rises above that of the lake, brackish water enters. This water, however, does not mix with the fresh water but essentially forms well-defined beds in the upper water layers which are sooner or later carried off by the outward-flowing current. To some extent the brackish water comes to rest on the bottom in the deepest parts of the basin. Such brackish bottom layers occur as far as 20 kilometers (12.5 miles) up the lake and are removed only when storms agitate the water so strongly that the brackish beds rise to the surface. Under normal conditions during 1909–1911 the proportion of salt in the deep holes in the part of Mälaren called Ekeröfjärden, 10 kilometers west of Stockholm, was 0.2 per cent; while in the Trälhavet, a bay of the Baltic 20 kilometers northeast of Stockholm, at a depth of about 10 meters, the proportion was 0.5 per cent.

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[17] Klas Sondén: Vattnet i sjöar och vattendrag inom Stockholm och dess omgifningar, *Bihang 2 till Stockholms stads hälsovårdsnämnds årsberättelse 1910*, Avd. 1, 1912. Stockholm.

We may now apply these principles to the conditions which obtained in late-glacial time.

Application to Conditions in Late-Glacial Time

When the land ice left the southern part of the Baltic basin, it was of course replaced by fresh ice water. As the recession went on, the growing lake received enormous supplies of fresh water from its large drainage area. By the tilting of the land the waters were shifted southward, creating strong outward-flowing currents through the Öresund, the sounds in central Sweden, and perhaps in other places, diluting the water in the Western Sea and holding back the incoming currents.

When the receding ice border uncovered the Fehmarn Belt, that channel stood at a high level. After the highest elevation had been reached it was submerged, until it finally became so deep that a salt undercurrent could force its way through the strait into the Baltic basin. Judging from the present conditions at the entrances to the Baltic, its depth was then more than 10 meters, perhaps 15 meters. Consequently this may have happened in late Ancylus time, for the region had reached its present level at the maximum of the Littorina subsidence, as shown by shore lines, shell beds, peat bogs, etc.

The changes in the level of the southern Öresund are little known, but it seems likely that the region in late-glacial and early post-glacial times for long periods lay higher than now. At the beginning of the fini-glacial epoch, indeed, it stood considerably higher.

During late-glacial and early post-glacial times, consequently, it is probable that no sea water passed in through the Fehmarn Belt and only an inconsiderable quantity through the Öresund. Incomparably more brackish water must have forced its way in through the sounds which, in fini-glacial time, existed in central Sweden. These sounds were wider and several times as deep and, furthermore, were situated directly opposite the Skagerrack and North Sea. They, however, were relatively short-lived and had, as indicated by the subfossil fauna and flora as well as by the sediments, only inconsiderable and local influence on the salinity of the Baltic.

After coming in through the straits, part of the brackish water probably settled down in the nearest deep basins and remained there for a long time more or less unmixed with the fresh water. Another part spread along the bottom over the central Swedish lowland and, probably, the southwestern district of Finland. Still another part was immediately carried off again by the strong outflowing current.

With the brackish water came a scanty marine fauna and flora, represented by forms which can endure strongly diluted water and which no doubt lived principally in the saltiest bottom layers: *Portlandia* (*Yoldia*) *arctica*, a few foraminifera, *Phoca groenlandica*, *Cottus quadricornus*, *Gammaracanthus loricatus*, *Idothea entomon*, etc., and a few diatoms.[18] Portlandia was represented by a stunted form indicative of too high temperature and too diluted water. It was limited to the Mälar depression and lived close to the receding ice border. In the Stockholm region it existed for less than 100 years.[19] Consequently, it is unfortunate to distinguish, as Munthe has, a stage in the history of the Baltic as "Yoldia time."

When and by which way some marine forms found at Kalmar, in southern Sweden, immigrated,[20] and what rôle the connection of the Baltic with the White Sea via Ladoga and Onega played, seems to be too little known to be discussed.

As Scandinavia underwent a mighty upheaval the central Swedish sounds grew shallow, and the inflow of brackish water became less and less. By storms and circulation the brackish water was gradually brought up into the upper water layers and thence carried out to sea. Finally, during Ancylus time, the Baltic, even in the central Swedish region, became practically fresh.

The highest salinity of the Baltic, reached during the Littorina subsidence, was, as far as known, synchronous with the one time when both the Darsser Schwelle and the threshold in the southern Öresund lay so deep that salt undercurrents could normally pass across them. The Fehmarn Belt then stood at about the same level as now, or 18 meters deep, while the southern Öresund lay about 5 meters lower than now, i.e. was 13 meters deep. The water outside the threshold, in the Cattegat, was at that time, as shown by the subfossil molluscan fauna, salter than during any other late-Quaternary phase and considerably warmer than at present. Its high temperature and relatively low gravity was, probably, an essential reason for its effective mixing with the Baltic water.

When the Öresund region and the Danish peninsula rose, the salinity of the Baltic slowly decreased to its present percentage.

So it seems quite possible that the surface layers and the main mass of the Baltic during Ancylus time consisted of fresh water, even though there had been connection with the ocean during most of the time since the Danish Islands became free of ice. The transgression of Ancylus time within the Baltic can be explained by subsidence of land instead of by a rising of the water within a closed basin during a mighty and long-continued upheaval and tilting of the land. This view is directly supported by recent observations in western Sweden. At several points around lake Vänern, Von Post[21] has found an old shore line which undoubtedly corresponds to the limit of transgression in the Baltic region during Ancylus time and thus proves that the Ancylus transgression was due to a sinking of land. In the Christiania region and in Bohuslän there are similar evidences of a subsidence contemporaneous with the Ancylus transgression.

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[18] See H. Munthe: Studies in the Late-Quaternary History of Southern Sweden, *Geol. Fören. Förhandl.*, Vol. 32, 1910, pp. 1197–1293; reference on p. 1236. Stockholm.

[19] Gerard De Geer: Finiglaciala Yoldia-relikter, *Geol. Fören. Förhandl.*, Vol. 35, 1913, p. 307. Stockholm.

[20] See Munthe, *op. cit.*, p. 1235.

[21] Lennart von Post: Ett finiglacialt granfynd i södra Värmland, *Geol. Fören. Förhandl.*, Vol. 40, 1918, pp. 19–25. Stockholm.

Changes of Level in the Baltic Basin

REGION SOUTH OF THE ISOBASE OF ZERO

The South Baltic and North Germany, south of the isobase of zero. probably stood highest shortly after they were relieved of the ice. As has been explained (p. 603), the exact elevation is unknown but was probably more than 35 meters above the present. Since the withdrawal of the ice North Germany seems to have undergone an almost uninterrupted slow subsidence, until the present level was reached at the climax of the Littorina submergence.

CENTRAL BALTIC REGION

It seems evident that similar changes in level took place simultaneously in western and eastern Sweden. Western Sweden, lying on the sea, affords the decisive evidence as regards the direction of the movements.

In Bohuslän the following changes of level seem to have taken place.[22] When the ice uncovered the coast and the marine limit was recorded, an intense and extensive uplift was already in progress. The elevation was followed by subsidence in late goti-glacial time, i.e. when the ice receded south of lake Vänern. At the end of the goti-glacial and beginning of the fini-glacial epoch the region once more was rising. This second emergence was interrupted by a fini-glacial sinking. During the latter part of the fini-glacial epoch the land rose for a third time, only to undergo a new submergence in early post-glacial time. After a fourth subsidence (Tapes submergence) the tract finally rose to its present level, which was reached at the beginning of the Iron Age, or about 500 B. C.[23]

The late goti-glacial subsidence is that one observed by De Geer[24] at Kapellbacken, Uddevalla, but dated by him wrongly, I think, as fini-glacial. The fini-glacial submergence here recognized is new. The early post-glacial subsidence has been recognized for some time in southeastern Norway but is new for Bohuslän. The Tapes submergence has long been known.

As pointed out, all these oscillations should have had their parallels in eastern Sweden, in the Central Baltic region.

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[22] Ernst Antevs: Senkvartära nivåförändringar i Norden, *Geol. Fören. Förhandl.*, Vol. 43, 1921, pp. 642–652 Stockholm.

[23] Otto Frödin: En svensk kjökkenmödding, *Ymer*, Vol. 26, 1906, pp. 17–35; reference on p. 33.

[24] Gerard De Geer: Quaternary Sea Bottoms in Western Sweden, *Geol. Fören. Förhandl.*, Vol. 32, 1910, pp. 1139–1195. Stockholm.

The goti-glacial subsidence has not yet been established within the Baltic, but we can expect to find it registered in northern Småland and southern Östergötland.

The fini-glacial submergence has also been proved on Mt. Billingen[25] and at Karlsborg on lake Vattern.[26] To this subsidence should be attributed, probably, also the well-marked shore line in southern Finland which Ramsay[27] has interpreted as the marine limit after the drainage of the Baltic ice lake at Billingen. This view seems to be supported by a newly discovered fact. At the northern end of Billingen Lundqvist[28] determined the limit of the Baltic ice lake at a height of about 149 meters, the marine limit at 132 meters, and the fini-glacial limit at 117–119 meters. The difference in the level between the Baltic and fini-glacial limits is, consequently, 30–32 meters; and that between the marine and fini-glacial ones 13–15 meters. At Karlsborg the Baltic limit lies at 153[29] and the fini-glacial at 118–123 meters.[30] The difference of level is 30–35 meters. On the inner Salpausselka in southern Finland Ramsay[31] found well developed shore lines, which he interprets as the marine limit, 31–34 meters below the limit of the Baltic ice lake; and a little north of the Salpausselkä he found other terraces, in his opinion marking an interruption in the drainage of the ice lake, about 12–13 meters above the shore lines just mentioned. Thus Ramsay's "marine limit" seems to be better conceived of as the fini-glacial limit, and his less developed terraces as the marine limit after the drainage.

The early post-glacial subsidence seems to be identical with the Ancylus transgression, which, I think, is now fully proved to be due to subsidence of land and which may be early post-glacial instead of fini-glacial, as has generally been assumed.[32]

The Tapes submergence on the west coast was contemporaneous with the Littorina subsidence in the Baltic.

SOUTHERN BALTIC NORTH OF THE ISOBASE OF ZERO

The changes of level in southernmost Sweden and eastern Denmark have not yet been satisfactorily worked out. Thus, we do not know how many oscillations there have been nor what limits they have reached. However, it seems likely that the region has undergone all the oscillations that have occurred in Bohuslän and the central Baltic, and possibly earlier ones.

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[25] G. Lundqvist: Den baltiska issjöns tappning, *Geol. Fören. Förhandl.*, Vol. 43, 1921, p. 385. Stockholm. Also oral information by Dr. Simon Johansson.

[26] Lundqvist, *op. cit.*, p. 385.

[27] Wilhelm Ramsay: De s. k. marina gränserna i södra Finland, *Fennia*, Vol. 40, No. 7, 1917. Helsingfors. *Idem: Geol. Fören. Förhandl.*, Vol. 43, 1921, p. 495. Stockholm.

[28] Lundqvist, *op. cit.*, p. 382.

[29] Munthe, *op. cit.*, Pl. 47.

[30] H. Hedström: Om ändmoräner och strandlinjer i trakten af Vaberget, *Sveriges Geol. Unders.*, Ser. C, No. 188, 1901. Stockholm. Interpretation Lundqvist, *op. cit.*, p. 385.

[31] Ramsay, *Geol. Fören. Förhandl.*, Vol. 43, 1921, p. 495. Stockholm.

[32] Antevs, Senkvartära, p. 652.

CENTRAL REGION OF THE UPHEAVAL DISTRICT

When the peripheral districts were rising the more central ones were still depressed, nor do the later oscillations seem to have been contemporaneous in the whole district of upheaval. Thus, it is generally assumed that undulating movements of the crust of the earth advanced from all sides toward the center of the Scandinavian peninsula. Before reaching there, however, they seem to have lost themselves in an intense and unbroken elevation.[33]

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[33] R. Lidén: Om isavsmältningen och den postglaciala landhöjningen i Ångermanland, *Geol. Fören. Förhandl.*, Vol. 33, 1911, pp. 271–280. Stockholm.

Idem: Geokronologiska studier öfver det finiglaciala skedet i Ångermanland, *Sveriges Geol. Unders.*, Ser. Ca, No. 9, 1913. Stockholm.